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(54) "SELF-PROPELLED MILITARY VEHICLE"

(71) We, DORNIER SYSTEM GmbH, a German limited liability company, of Postfach 1360, 7990 Friedrichshafen 1, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a self-propelled military vehicle, for example a tank.

The majority of military vehicles, especially tanks, are lost in battle not as a result of a direct hit but as a result of a fuel tank being hit, leading to an explosion or to the tank burning out. Secondary explosions and instant generation of heat in the tank also in most cases prevent the crew gaining safety if the petrol tank of a tank is hit by an otherwise relatively harmless projectile.

The invention is based on the problem of operating a self-propelled military vehicle with a substantially incombustible fuel, employing a fuel tank in which the propellant does not catch fire nor give rise to secondary explosions when a shot hits the fuel tank.

According to this invention, there is provided a military vehicle having one or more fuel tanks, wherein the or each fuel tank contains a material which stores hydrogen and gives off the hydrogen, when heated to above ambient temperature, for supply to a driving engine operable on hydrogen.

In the case of a vehicle having a conventional driving engine, it is known to use, instead of liquid hydrocarbon, hydrogen as the fuel. The reason is that in future adequate liquid hydrocarbon fuel produced from petroleum may no longer be available. On the other hand, there are prospects that in future hydrogen, produced for example by temperature electrolysis, may be more economical to produce in large quantities. A disadvantage of using hydrogen as a driving agent however is that the use of highly pressurised gaseous or liquefied oxygen is prohibitive; also fuel tanks with storage material for hydrogen would occupy at least four times the volume compared with hydrocarbon tanks. Since also the weight of the storage materials is high, the power to weight ratio and radius of action of a vehicle would be reduced by the use of a hydrogen drive.

Suprisingly, however, it has been found that when a shot hits or passes through a hydrogen tank, there is little or no fear of explosion or fire. If a fuel tank is perforated, then pressure and temperature drop immediately so establishing a reaction balance which prevents further gasification of the storage material. Only in quite isolated cases may an oxyhydrogen gas explosion occur outside the hydrogen fuel tank it it is hit, but such an explosion does not spread and is relatively harmless.

The disadvantage of high weight of a fuel tank filled with a storage material, which is otherwise present when hydrogen is used as a propellent, may, in the case of a self-propelled military vehicle be an advantage, in that the hydrogen tank can be used for armouring the vehicle against projectiles, and can comprise double-wall parts braced by bulkheads. In particular, the hydrogen tanks may be used for armouring the floor or the roof or top of the vehicle.

Tanks usually have armour plate at the front and for shots coming from up to about 45° from the side. They are fairly vulnerable when fired upon from above and also to for example hollow-charge mines and impact projectiles which can pierce the floor plating. If therefore hydrogen tanks are mounted on the floor plating, then on the one hand the armouring of this endangered part is improved and on the other, the centre of gravity of the vehicle is moved down sufficiently that its terrain negotiating ability is enhanced.

The hydrogen tanks may be disposed at those locations where neutron radiation protection is required. In experiments, it has been found that the storage materials in the hydrogen tanks offer considerable resistance to the passage of neutron radiation. In the present case, this effect is exploited in that the fuel tank serves on the one hand as a container for storing fuel and on the other as a protective casing against shots and radiation.

The hydrogen tank may be filled with metals, e.g. titanium ferrite or lanthanum nickel. These storage substances have proved satisfactory under test and can be used. Future developments may well lead to other storage materials which may then be advantageously employed. At present magnesium is not suitable as a light-

weight storage material, since it is combustible. It is possible that in future magnesium-based incombustible storage materials may be developed, so as to offer good storage capacity with low dead weight, so that the power to weight ratio of a vehicle is only slightly reduced by the storage materials.

In one embodiment, the storage materials may be solid porous bodies, which are for example sintered together. Such sintered bodies give good mechanical protection particularly against impact projectiles.

Individual hydrogen tanks, braced in respect of one another by bulkheads, may be filled with different types of storage materials. Since the different storage materials give off hydrogen gas at different temperatures, in the event of a cold start gas may be obtained from one fuel tank and a different fuel tank may supply the fuel during continuous operation. Special fuel tanks for starting-up may be filled with storage materials which release hydrogen gas accumulated in them at relatively low temperatures. If the ambient temperature is inadequate for this purpose, electric heaters may be used for pre-heating. Thus even at very low outside temperatures, the armoured vehicle is always ready for action.

The storage material may be heated by heat lost by the engine and a pressure sensor inside the fuel tank may interrupt the supply of heat to the fuel tank in the event of the latter leaking due to projectile impact. For the supply of heat, for example the engine exhaust pipes may extend through the fuel tanks, or heat exchangers or heat pipes may be so located that the storage materials are heated sufficiently from the ambient temperature. The required quantity of heat is readily meterable *via* a thermostat and quantity flow control device. A virtually closed heat balance is desirable, in which the heat lost in exhaust gas and by cooling of the engine is fed almost entirely to the storage materials.

In addition to the hydrogen tanks and the hydrogen engine, a conventional engine and disposable and/or rigidly installed tanks for liquid hydrocarbons may be provided. The main driving engine may also be constructed as a multi-fuel engine which can be operated with both hydrogen gas and a gasiform liquid hydrocarbon. Where there is no danger of its being fired upon, the armoured vehicle may use conventional fuel located in dumpable containers, for example at the rear. At the start of battle, the fuel tanks, preferably drums, would be dumped and the vehicle would then operate solely with hydrogen gas. The remaining range of operation will as a rule be sufficient for quite prolonged combat, since in most cases combat involves only a fraction of the total range of the tank.

The invention will now be described by way of example with reference to the drawings, in which:—

Figure 1 is a side elevation of a tank;

Figure 2 is a perspective sketch showing the principle underlying the use of hydrogen tanks in an armoured vehicle; and

Figure 3 is a diagram showing the principle underlying the operation of an engine by gas derived from hydrogen tanks.

Referring to Figure 1, a tank 2 comprises a hull 4 with a chassis 6 and tracks 8, an engine 10, a turret 12 and a gun 14. The hull 4 is armour-plated at the front 16 and its other areas are of steel plate.

If an engine which can be operated by hydrogen gas is used as the driving engine 10, then tanks 18 (Fig. 2) having storage material 20 for hydrogen gas are used. In the present embodiment, the bottom 22 of the vehicle 2 is double-walled and filled with storage materials, e.g. titanium ferrite or lanthanum nickel. The bottom 22 thus has two walls 24, 26 and is divided into various tanks 18 by bulkheads 28. Different storage substances may be contained in the individual tanks.

Figure 2 also diagrammatically shows the layout of the hydrogen tanks 18 and a supply pipe 30 for filling the tanks *via* connections 32, 34, 36, 38. Hydrogen gas is drawn from the tanks *via* draw-off pipes 40 to 46 which discharge into a main pipe 50.

The pipe 50 is also seen in Figure 3. It leads to the engine 10 and supplies it with hydrogen gas as the driving medium. The engine is illustrated diagrammatically; it has a casing 54, cylinder head 56 and output shaft 58. The several exhaust gas outlets discharge into a main exhaust pipe 60 from which a branch pipe 62 runs to the tanks 18 and passes through them. The gas quantity flowing through the branch pipe 62 is regulated by a thermostat 64 on the engine and a flow valve 66, the gas quantity flowing through the gas feed pipe 50 is measured at 65, and a slide valve 68 located at the end of the main exhaust pipe 60 is operated by a control line 70. During starting-up, the entire heat of the exhaust is passed through the fuel tanks 18 in order to achieve in them a level of temperature sufficient to provide for reliable flow of gas to the engine. If the exhaust heat is not sufficient for this purpose, then the storage material is heated by an electric heater (not shown).

If one of the fuel tanks 18 is fired upon or pierced by a projectile, the corresponding parts of the piping can be shut off by hand or for example by means of pressure sensors which indicate the pressure drop in the tank. It is therefore advisable for the filling arrangement, the gas delivery pipes and also the heat pipes (or heater conductors) of the individual fuel tanks to be connected in parallel or for the fuel tanks to be connected together in groups, which are then connected to one another for parallel operation.

The oxyhydrogen gas explosion mentioned above, which may occur when one of the fuel

tanks is fired upon, may be rendered harmless in that at least the parts of the tank walls which bound the compartment in which the crew of the armoured vehicle is present, are lined with an elastic material (for example a polyethylene film several millimetres thick). If a hit is scored on a fuel tank of this type, then the entry hole in the wall of the armoured vehicle and the fuel tank will remain open, so that any pressurised hydrogen gas can escape with a harmless explosion of oxyhydrogen gas, whereas the exit hole in the fuel tank will close again at once by reason of the elastic film so that there will be no fear of an oxyhydrogen gas explosion inside the armoured vehicle.

WHAT WE CLAIM IS:–

1. A military vehicle having one or more fuel tanks, wherein the or each fuel tank contains a material which stores hydrogen and gives off the hydrogen, when heated to above ambient temperature, for supply to a driving engine operable on hydrogen.

2. A vehicle according to Claim 1 having a double-walled part containing the or each fuel tank.

3. A vehicle according to Claim 2 wherein the double-walled part is sub-divided by bulkheads.

4. A vehicle according to any preceding claim wherein the tanks serve to armour the bottom and/or top of the vehicle.

5. A vehicle according to any preceding claim wherein the tanks are disposed at places on the vehicle where neutron radiation protection is needed.

6. A vehicle according to any preceding claim wherein the or each tank is filled with metals, for example titanium ferrite and lanthanum nickel, for storing hydrogen in hydride form.

7. A vehicle according to Claim 6 wherein the storage material comprises solid porous bodies, which are for example sintered together.

8. A vehicle according to any preceding claim wherein individual tanks are filled with different types of storage materials.

9. A vehicle according to any preceding claim wherein the storage material is heated by heat loss from the engine.

10. A vehicle according to Claim 10 wherein supply of heat to a tank or tanks is interruptable by a pressure sensor which senses tank pressure.

11. A vehicle according to any preceding claim wherein heat-conveying pipes pass through the fuel tanks.

12. A vehicle according to any preceding claim wherein the storage material or materials is or are heated by a heat pipe or pipes.

13. A vehicle according to any preceding claim wherein, in addition to the hydrogen tank or tanks and the hydrogen engine, a conventional engine is provided, together with disposable and/or rigidly installed fuel tanks for liquid hydrocarbons.

14. A vehicle according to any preceding claim wherein the driving engine is suitable for use as a multi-fuel engine for operation on hydrogen or hydrocarbon.

15. A vehicle according to any preceding claim wherein the walls of the or each hydrogen tank are at least partially lined with an elastic material.

16. A military vehicle constructed and arranged substantially as herein described and shown in the accompanying drawings.

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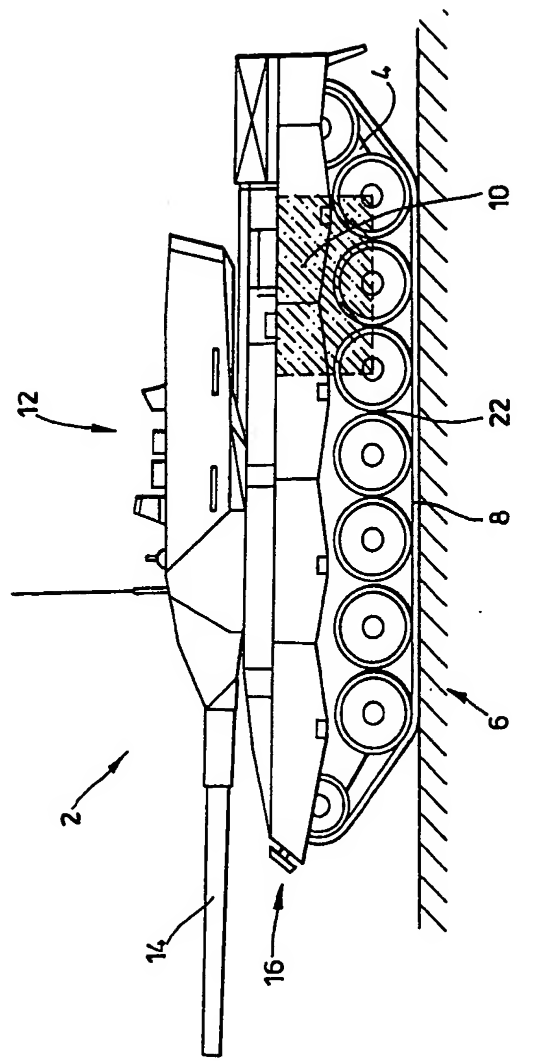

FIG.1.

Fig.2.

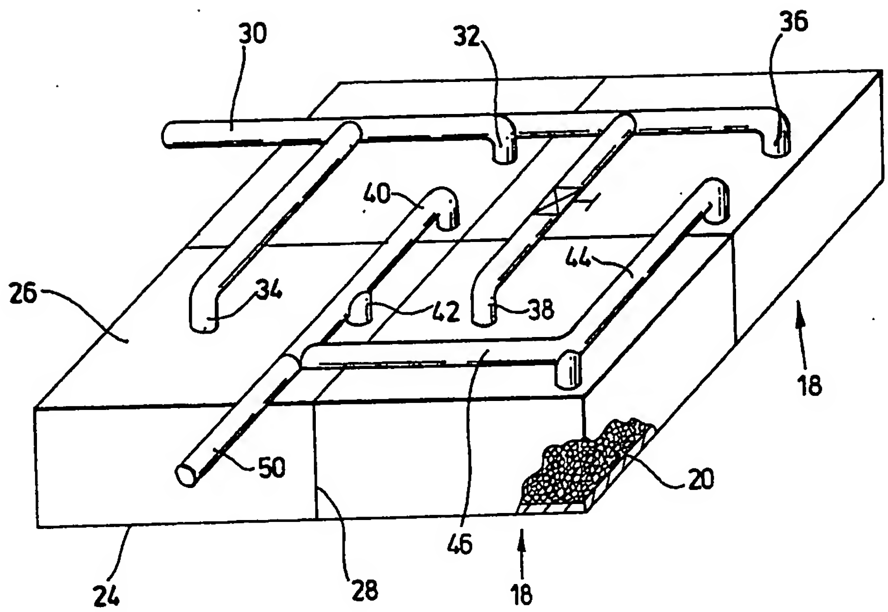
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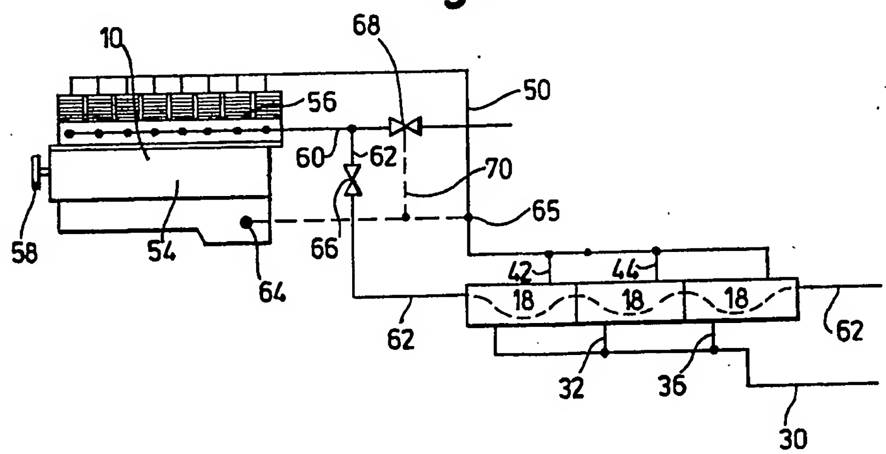
Fig.3.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